

DRAFT Outline July 8<sup>th</sup> 2010

## **Appliance Socket Interface**

prepared by

Conrad Eustis, Portland General Electric

edited by

Dr. Kenneth Wacks\*, [www.kenwacks.com](http://www.kenwacks.com)

prepared for

GridWise Architecture Council / NIST / SGIPGB

by the

Home-to-Grid Domain Expert Working Group

July 8, 2010

\* Member, GridWise Architecture Council, U.S. Department of Energy

### **Introduction**

Appliance makers and utilities know little about 2-way demand response use cases for “smart” appliances. We do not have a retail business model in demand response for “Crossing the Chasm<sup>1</sup>” from trials to mass-market deployment. What we need is flexibility to learn customer requirements over the next several years while being able to introduce appliances today that will not be obsolete as new demand response programs are launched over the next 15 years.

The premise of these requirements is that physical sockets are the most enduring of all information interfaces. PCI and the PC serial interface are two good examples of interfaces in use for more than 15 years. USB, while relatively new, is the most successful information interface.

---

<sup>1</sup> See: [http://en.wikipedia.org/wiki/Crossing\\_the\\_Chasm](http://en.wikipedia.org/wiki/Crossing_the_Chasm)

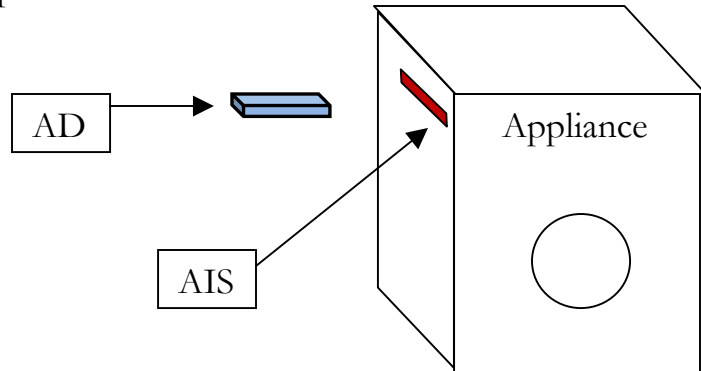
## **Definitions**

AIS = Appliance interface socket: A standardized physical and logical interface on the appliance.

AD = Appliance Dongle [a communication device that plugs into the AIS]

OEMs = Appliance Original Equipment Manufacturers

DR = Demand Response



## **General Requirements and Principles**

AIS design must be cost effective for low end appliances. Many of the most suitable appliances for demand response; namely, dehumidifiers, window AC units, dryers, water heaters, pool pumps, refrigerators, freezers, etc. have no digital controls today. The EPRI Demand Response Socket Project interviewed the OEMs. While many liked the idea of a simple command set (SCS) (much simpler and shorter than the SEP command structure) none preferred a pure Boolean pin implementation approach but instead want a standard, short (e.g. 4 byte) digital signal packet approach.

Complexity in the AD is preferred to adding requirements with increasing cost implications for the AIS.

The most basic commands should afford autonomy to OEMs to design an appropriate demand response. The commands are really more like a request or just information to the appliance. Appliance logic, together with input from the customer interface, determines how the appliance actually responds to a given signal.

## **Customer Requirements**

The AD must be customer installable and removable.<sup>2</sup> Crossing the Chasm for broadband did not occur until cable and DSL providers could distribute a self-install option.

---

<sup>2</sup> Implicit in this requirement is the fact that the customer can always override any communication signal by simply removing the device. While some people object, for devices in the home there is no way to stop a customer from defeating a non-override approach.

While not a requirement, the philosophy of the standard must anticipate “set and forget” setting on the appliance by the consumer. To date energy is a low involvement subject for most customers. If we want adoption we must allow this behavior.

### **AIS Physical Requirements**

AIS must power the AD. Initial research by EPRI indicates two separate physical form factors are required. A small form factor for a DC powered dongle, and a larger form factor for 120- to 240-volt AC-powered dongle. The specification must clarify voltage ranges and min and max milliamps of the supply as well.<sup>3</sup> It must also include minimum physical dimension specs and clearances for the volume that the AD will occupy

Most aspects of user safety, aesthetics and mechanical connection of the AD to the appliance should be left to appliance OEMs

OEM's have the responsibility to determine the location of an AIS on the appliance; it is not unreasonable to have to unfasten an access plate on an internal or external surface. (E.g. consider changing an oven light bulb.)

---

<sup>3</sup> This is a challenging requirement because of UL requirements and issues like hot water heaters commonly support L1, L2 and ground (no neutral). This means that without a costly transformer or power supply only 240/208 volts is available. Accommodating PLC communication technologies requires access to line power as well.

## **Logical Requirements**

Start with a simple command set (SCS) but make it **Extensible** for multiple and more advanced protocols like Climate Talk, SEP 2.0, and even allow for Internet traffic if a future appliance can support it. See Appendix A for an example of a simple command set.

## **Extensibility<sup>4</sup>**

Appliances will vary in their ability to comprehend and initiate commands. Definitions about the classes of these devices must be decided early in the standard specification process to allow for extensibility in the future. Appendix B gives an example of appliance classes and their differing roles and responsibilities.

PHY/MAC Layer Defined for extensibility in 5 address spaces domains

1. Interface communications, handshaking, mutual identification, heartbeat etc. (these commands evolve over time thru a standards process)
2. Utility Command Set (Utility industry evolves these commands over time thru standards process) (OpenHAN and SEP2 would map into this space over time via subsequent releases of the spec)
3. Appliance OEM Command Set (Appliance OEMs evolve these commands over time thru a standards process like Climate Talk)
4. Appliance OEM Proprietary Command Address Space; An appliance OEM get exclusive control over these addresses for advanced features and/or value-added services (*? Do we need separate address spaces for each OEM or 1 space with a header code for each unique OEM*)
5. Sandbox Command Address space; used for pilot or custom implementations. No guarantee of forward or backward compatibility.

Handshaking Requirement AD Requests appliance to Identify its “Kind” via the serial command. No response implies Appliance of the First Kind. A response of 2, 3, or 4 implies and an appliance of the Second, Third, or Fourth Kind respectively. The AD is the Master device but every minute or so it gives appliances of 2, 3 & 4 kind an AD health status message and asks for an ACK. Appliances of 4<sup>th</sup> kind might initiate a conversation.

## **Appliance OEMs determine the actual Demand Response**

We should leave appliance response to the appliance OEMs. Appliance OEMs have never had the motivation to optimize appliance energy use by time-of-day or to create a user-interface to make it easy to shift energy use to non-peak hours.

---

<sup>4</sup>This is an example of concerns that need to be addressed by a future PAP; this is not a specific recommendation.

Like most electric customers, the engineers that design appliances have lived with time-unchanging electric price for 100 years. Design engineers at appliance OEMs need some autonomy. The electric industry needs to define a list of industry needs they feel the appliance can help mitigate. How and whether an appliance can support these needs should be left to the OEMs

## Appendix A Example of a Boolean-like Simple Command Set (SCS)

### Initial Signals that the AD would present to an Appliance

Not all commands must supported by appliance

For Version 1.0 signals are Boolean like; no actual data is passed.

	Name	Meaning
1	Simple Off	
2	Grid Emergency	Suppress Load as long as possible or until clear signal. E.g. a stove burners might go off for only 30 seconds
3	Critical Peak	A very unusual event where very high price exists; maximum duration 5 hours
4	High Price	Used only with at least a second lower Price signal; maximum duration 8 hours
5	Normal or Medium Price	Can be used by without other prices to mean return to unrestricted appliance operation; unlimited duration
6	Low Price	Used only with at least a second higher Price signal; unlimited duration
7	Cancel Last	Similar to Normal Price but explicitly cancels previous signal
8	AD Healthy	Means AD is Connected to a HAN or WAN
9	No Comms	Means AD never established or has lost HAN/WAN comms
10	Adv. Higher	Means a change to a higher price expected in 2 hours
11	Adv. Lower	Means a change to a lower price expected in 2 hours
12	Sunday	Signals Sunday at 00:00:01
13	0400	Signals local time is 04:00:01 (daily to correct timer drift and DST)

### Initial Signals that the AIS *might* present to an Appliance

For Version 1.0 signals are Boolean like; no actual data is passed.

	Name	Meaning
1	ACK	Appliance acknowledges last Signal
2	2 <sup>nd</sup> Kind	I am an Appliance of the 2 <sup>nd</sup> Kind
3	3 <sup>rd</sup> Kind	I am an Appliance of the 3 <sup>rd</sup> Kind (not supported V1.0)
4	4 <sup>th</sup> Kind	I am an Appliance of the 4 <sup>th</sup> Kind (not supported V1.0)
5	NACK	I do not comprehend the last signal
6	Customer Priority	Customer has elected to continue normal operation of appliance. AKA the customer override implemented
7	Service	Appliance is in need of a service repair
8	Operating	Means Appliance is operating in a standard mode above the standby power level
9	Low Power	Appliance in rest still but communication still possible
10	Sleep	Appliance will be powered down soon and unable to ACK any signal

## **Appendix B Example of Appliance Control Paradigms**

The specification begins with the definition of four control paradigms. To accelerate implementation Versions 1.0 would only define specifications for the first control paradigm and basic Boolean-like commands for the second paradigm. All versions use the same serial data link technique.

### **Appliances of the 1<sup>st</sup> Kind**

Limited electronics. Spec includes only 1 to 3 states from SCS besides; normal. AD signals are 1-way requests; there is no requirement for appliance to even ACK, but desirable. Appliances comply if they understand the command. The appliance OEM implements whatever load reduction they believe is appropriate. These appliances “trust” the signal. The consumer, in adding an AD to this type of appliance, needs to trust their signal provider. The appliance may, or may not, have a user interface (or additional embedded appliance logic) to disable the remote communication signals. Of course, the consumer can always unplug the AD.

### **Appliances of the 2<sup>nd</sup> Kind**

Basic electronics in Appliance. Version 1 of specification would support about 8 to 16 of the commands in the SCS utility including the 2 to 4 states defined for Appliance of the 1<sup>st</sup> Kind. Key difference between the 2<sup>nd</sup> Kind and the 3<sup>rd</sup> Kind is that the appliances exert autonomy; they may respond to a command (or not) but they do not have to support security requirements; the assumption is that these are provided by an AD. This class does not have to manage the more complex standard like SEP 2.0; the AD has the responsibility to provide mapping from SEP 2.0 to SCS.

### **Appliances of the 3<sup>rd</sup> Kind**

Sufficient Micro capability in appliance. In Version 1 of Spec standard defines about 8 to 16 utility commands. (See recommendations below) The key difference between the 2<sup>nd</sup> Kind and the 3<sup>rd</sup> Kind is that this group depends on the AD only for security and FAN/HAN linkage. Specifically the appliance will interpret SEP commands directly; logic in the appliance will determine what, if any actions the appliance will actually implement. The appliance may or may not support revisions to evolving Standards; e.g., an appliance designed on basis of SEP 2.0, may or may not support SEP 3.0.

### **Appliances of the Fourth Kind**

Sufficient Micro capability in appliance.. Appliances at this level expect to initiate conversations with EMS or other devices on HAN. This paradigm allows for strict control of the appliance control via a home energy management system. Because so much can go wrong under this model and because we know so little about customer and utility needs in this model the Version 1.0 spec will not support EMS requirements